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Opinion Article

Protecting Soil Bacterial and Fungal Communities to Sustain Subtropical Forest Trees

Zexin Lu*

Department of Forest Conservation, Zhejiang University, Hangzhou, Zhejiang, China

DESCRIPTION

Soil microbial communities, composed of bacteria and fungi, form intricate networks that interact with tree roots, organic matter, and the surrounding environment. These microorganisms mediate critical ecological processes that sustain subtropical forest ecosystems.

Nutrient cycling

Bacteria and fungi drive the decomposition of organic matter, breaking down complex molecules into simpler forms that can be absorbed by tree roots. For example:

- Bacteria play a key role in nitrogen cycling. Nitrifying bacteria convert ammonium into nitrates, while nitrogen-fixing bacteria (e.g., Rhizobium) convert atmospheric nitrogen into forms usable by plants.
- Fungi, particularly mycorrhizal fungi, enhance phosphorus solubilization and uptake, as phosphorus is often a limiting nutrient in subtropical soils.

This nutrient cycling supports the growth and productivity of subtropical forest trees, influencing their overall health and biomass.

Symbiotic relationships with trees

Soil fungi form symbiotic associations with tree roots, particularly through mycorrhizal networks:

- Ectomycorrhizal fungi form a sheath around tree roots and extend hyphae into the soil, enhancing nutrient uptake and water absorption.
- Arbuscular Mycorrhizal Fungi (AMF) penetrate root cells, facilitating nutrient exchange and providing trees with essential minerals such as phosphorus and potassium.

These partnerships not only support tree nutrition but also improve resistance to environmental stresses such as drought and nutrient-poor soils.

Soil structure and water retention

Soil bacteria and fungi contribute to soil aggregation by producing extracellular polysaccharides and hyphal networks, respectively. These structures improve soil porosity, aeration, and water-holding capacity, creating an optimal environment for root growth. Subtropical forest trees benefit from improved access to water and oxygen, especially during dry seasons or extreme weather events.

Disease suppression and resilience

Soil microbial communities play a protective role against pathogens. Beneficial bacteria such as *Pseudomonas* and fungi like *Trichoderma* produce antimicrobial compounds that suppress soil-borne diseases. This microbial balance reduces the vulnerability of subtropical forest trees to infections, enhancing forest resilience.

Impact of soil microbial diversity on subtropical forest trees

The diversity of soil bacterial and fungal communities is a critical determinant of forest health. Greater microbial diversity promotes ecosystem stability and resilience by ensuring functional redundancy-different microbes performing similar roles to maintain ecological processes.

Species-specific interactions: Subtropical forest trees often have species-specific associations with soil microbes. For example, certain trees preferentially associate with specific mycorrhizal fungi, which influence their growth and competitive abilities. These unique interactions shape forest composition and biodiversity.

Succession and regeneration: Soil microbial communities influence the succession of subtropical forests by affecting seedling establishment and growth. Mycorrhizal fungi, in particular, are essential for the establishment of tree seedlings, as they provide nutrients and protect against pathogens in the early stages of growth. Changes in microbial communities due to

Correspondence to: Zexin Lu, Department of Forest Conservation, Zhejiang University, Hangzhou, Zhejiang, China, E-mail: luzexin52@xtbg.org.cn

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disturbances, such as logging or climate change, can disrupt natural regeneration processes.

Carbon sequestration: Microbial activity in the soil determines the rate of organic matter decomposition and carbon storage. Fungi, especially saprotrophic fungi, are major players in breaking down lignin and cellulose, influencing the amount of carbon retained in the soil. Subtropical forest trees, in turn, contribute to this process through leaf litter and root exudates that feed soil microbes.

CONCLUSION

Soil bacterial and fungal communities are fundamental to the health and productivity of subtropical forest trees. They mediate nutrient cycling, support symbiotic relationships, and enhance resilience against environmental stressors. However, these vital microbial networks are under threat from deforestation, climate change, and pollution. By understanding and protecting these microbial communities, we can promote the sustainability of subtropical forests and their role in global biodiversity and climate regulation. Sustainable management practices that integrate soil microbial health will ensure the long-term vitality of these ecosystems and the services they provide.